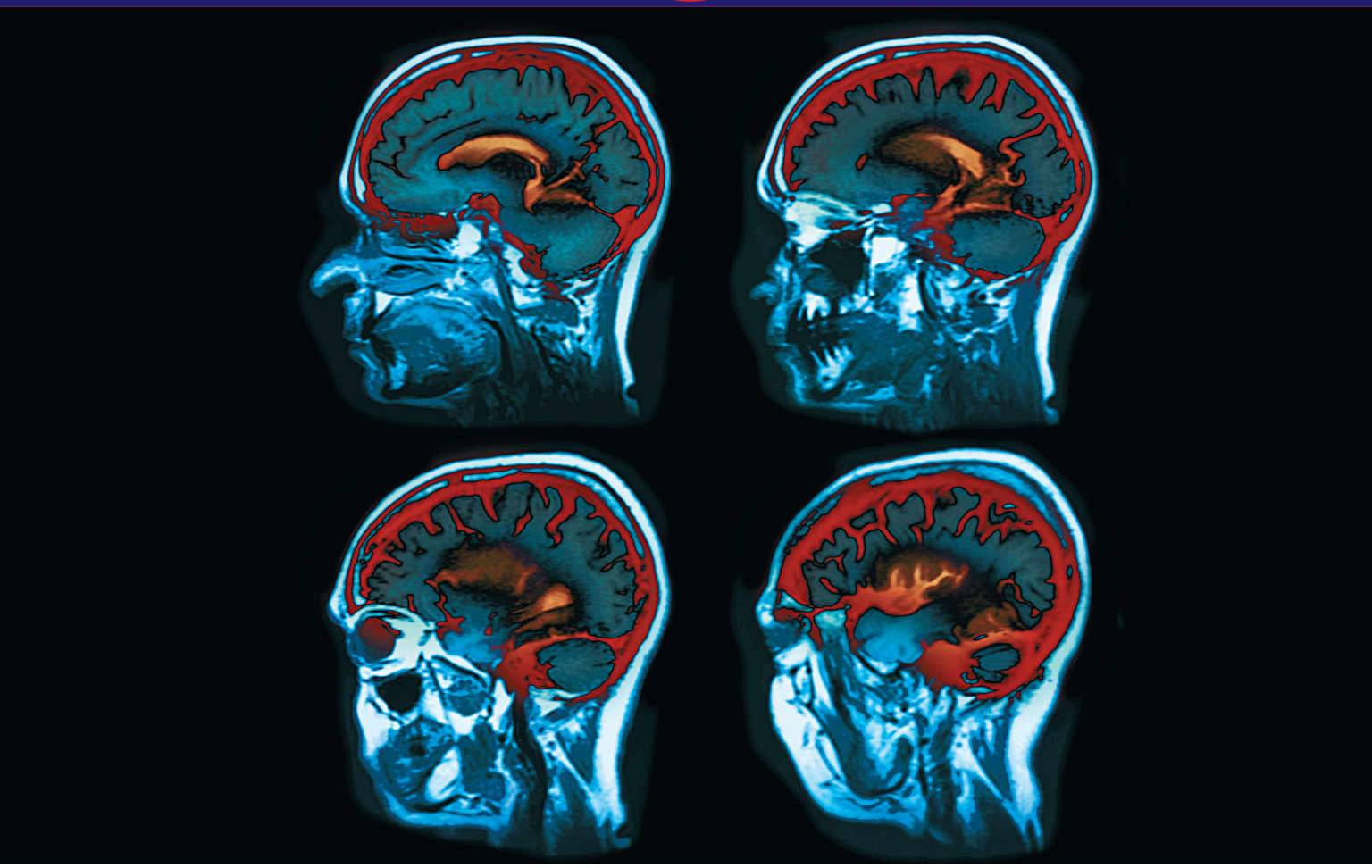


These magnetic resonance imaging (MRI) scans reveal four profile views at different depths of a healthy human brain. The folded cerebral cortex — associated with thought processes — is highlighted in red.

Scanning Technologies: Today and Tomorrow

An X-ray image of a tooth or broken bone is commonplace, and ultrasound images of a developing fetus are a regular part of prenatal care. Without the need for a single incision, various forms of non-invasive imaging technology provide clear images of the soft tissues of our bodies. Imaging technology also exposes the contents of locked luggage during airport security checks. Satellites circle Earth, relaying data about geological changes, volcanoes, hurricanes, and crop and vegetation densities.

Understanding the fundamental properties of matter, fields, waves, and energy has opened the door to hundreds of scanning technologies, and continuing research results in yet more scanning methods and continues to push the capabilities of these technologies to new heights. Research costs money, however, and is very time-consuming. Are these new scanning techniques worth the expense and time involved?

ASSESSMENT

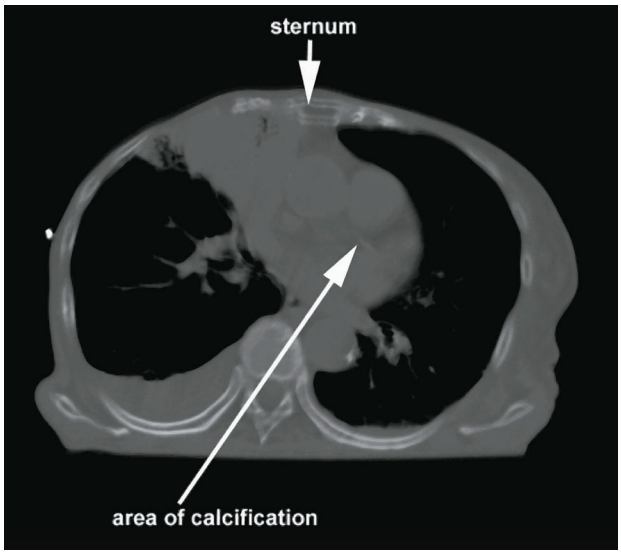
After you complete this Course Challenge, you will be assessed on

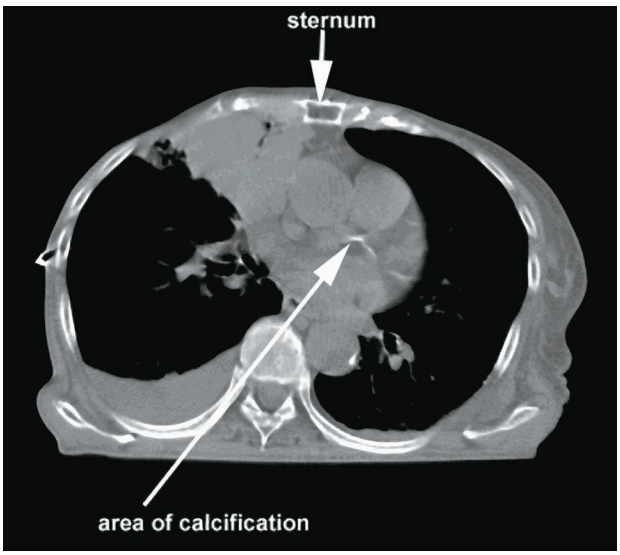
- **the quality of your research**
- **the accuracy and depth of your understanding**
- **your presentation**
- **other criteria you decide on as a class**

This Course Challenge prompts you to examine the costs and benefits of imaging technologies to both the scientific community and society. To help you get started, three fields of scanning technology and some associated issues are presented here.

Medical Issues

Doctors and politicians are often criticized when professional athletes gain access to magnetic resonance imaging (MRI) diagnosis immediately after sustaining an injury, while the general public must often wait months. Questions arise about the real expense of MRI equipment, its availability, and the value of the results as compared to other methods. How does an MRI machine work? What fundamental principles of nature does it exploit? Why is MRI scanning so expensive? Will the costs reduce with time? Will the technology improve with time? Are there better, less expensive options that should be pursued? Will this technology ever be made available to citizens of developing nations? To develop an argument supporting continued use of and research into MRI technology, you need to be able to answer these and other questions.





Motion, such as a beating heart or breathing, causes a blurring of conventional computerized tomography (CT) scan images. New computer technology, involving millions of frames of reference calculations, is able to remove the blur and produce much clearer images.

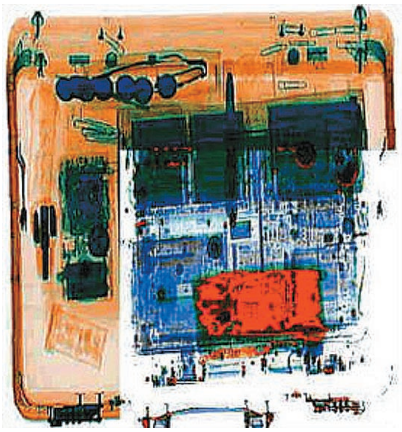
Photos courtesy of Dr. S. Stergiopoulos, Defence R&D Canada - Human Sciences, Toronto, Canada

PHYSICS FILE

A remote mountaintop in western North America rose 10 cm in four years, from 1996 to 2000. The 10 cm bulge is at the centre of a circle with a 12 km radius, and is only a few kilometres from the South Sister, a volcano that erupted 2000 years ago. The bulge is believed to be the result of growing pressure in an enormous chamber of magma beneath the mountain, and a telltale sign of potential volcanic activity. The 10 cm shift is a very small indicator of the tremendous amount of energy behind it, and would never have been detected without the remote-sensing ability of Earth-orbiting satellites.

Security Issues

Border-crossing and airport security often rely on technology to solve problems associated with screening large numbers of people and baggage in an efficient way. Some debate the effectiveness of the technological solutions compared to the enormous costs required to install and maintain the equipment. Opponents suggest that a human work force could do a more thorough and efficient job. Developing an argument supporting either side of this debate requires an in-depth understanding of the technology and its capabilities, and perhaps even a sense of its future potential.



A security imaging system can be set to detect the presence of explosives, narcotics, currency, or gold. In this case, the computer analyzed the contents of a laptop computer case and identified explosive material, indicated by the bright red area in this scan image.

Space Issues

Earth-orbiting, satellite-scanning technologies are used for environmental data collection, which is required for the development of sustainable agricultural, industrial, and even population-settlement plans. Weather satellites have allowed meteorologists to dramatically improve their forecasts. Surveillance satellites provide governments with information about covert operations.

A wealth of information comes from space, but the launching and maintaining of satellites is extremely expensive. World citizens need to be convinced that the economic costs associated with space-based research and related technologies are worth the rewards.

The Canadian Space Agency (CSA) and the U.S. National Aeronautics and Space Agency (NASA) devote a substantial amount of effort to global education, providing evidence of the benefits of space-related research. These agencies also work diligently to include other nations in large projects, such as the International Space Station. The CSA and NASA also recognize that projects must offer the global business community financial opportunities, as well as knowledge, to be successful in the long term. Does the commercialization of space fit with your vision of the future?

Debating which technologies are worth the investment of monetary and human resources can be accomplished only when all of the facts are known. Think about these questions as you undertake this Course Challenge.

Challenge

Develop and present a case either for or against the use of a particular scanning technology. You will use the knowledge and concepts you have acquired throughout this course, along with additional research, to develop your presentation about the economic, social, or environmental viability of a medical, industrial, or environmental scanning technology. Your class will decide together whether the presentations will be made through

- a formal debate
- research report presentations (either as a written report, an audiovisual presentation, or an information billboard)
- another format of your choice

Materials

All presentations are to be supported by your portfolio of research findings, the results of supporting experiments conducted, and a complete bibliography of references used.

Design Criteria

A. You need to develop a system to collect and organize information that will include data, useful mathematical relationships, and even questions that you use to formulate your final presentation near the end of the course. You can collect your own rough notes in a research portfolio.

B. Building a Research Portfolio

Your individual creativity will shape the amount, type, and organization of the material that will eventually fill your portfolio. Do not limit yourself to the items mentioned in the Course Challenge cues scattered throughout textbook; if something seems to fit, include it. The following are suggested items for your research portfolio.

- experiments you have designed yourself, and their findings
- useful equations
- specific facts
- interesting facts
- disputed facts
- conceptual explanations
- diagrams
- graphical organizers
- useful Internet site URLs
- experimental data
- unanswered questions
- pertinent economic or social statistics (Canadian or global)

C. As a class, decide on the type(s) of assessment you will use for your portfolio and for its presentation. Working with your teacher and classmates, select which type of presentation you will use to present your scanning technology arguments.

Action Plan

1. As a class, have a brainstorming session to establish what you already know and to raise questions about various scanning technologies that are currently being used or researched today. For example, what medical value does an MRI offer over other diagnostic methods, and is that difference worth the economic price? How widely available is MRI technology in **(a)** Canada or **(b)** other parts of the developed or underdeveloped world?
2. As a class, design an evaluation scheme, such as a rubric or rubrics for assessing the task. You could decide to assess specific components leading up to the final presentation, as well as the presentation itself.
3. Decide on the grouping, or assessment categories, for this task.
4. Familiarize yourself with what you need to know about the task that you choose. For example, if you choose a debate, it is important to research the proper rules of debating in order to carry out the debate effectively.
5. Develop a plan to find, collect, and organize in your research portfolio the information that is critical to your presentation.
6. Carry out the Course Challenge recommendations that are interspersed throughout the textbook wherever the Course Challenge logo and heading appear, and keep an accurate record of these in your portfolio.
7. When researching concepts, designing experiments or surveys, or following a Course Challenge suggestion in the textbook, you might find that the McGraw-Hill Ryerson Internet site is a good place to begin: www.mcgrawhill.ca/links/physics12
8. Carry out your plan, making necessary modifications throughout the course.
9. Present your arguments to your class. Review each presentation against the assessment criteria that you decided on as a class.

Evaluate Your Challenge

1. Using the assessment criteria you have prepared, evaluate your work and presentation. How effectively did your portfolio and presentation support your arguments? Were others able to follow your line of reasoning, based on the evidence, results, and conclusions you presented? How would you revise your presentation?

2. Evaluate your classmates' Course Challenge presentations.
3. After analyzing the presentations of your classmates, what changes would you make to your own project if you had the opportunity to do it again? Provide reasons for your proposed changes.
4. How did the process required to complete this challenge help you to think about what you have learned in this course?

Background Information

The following sections provide ideas to consider. They are linked to topics covered in the course and relate to the Course Challenge cues in your textbook. Your arguments will be both strengthened and redirected as you gain knowledge from each unit in this course.

Unit 1 Forces and Motion: Dynamics

Frames of Reference

Chapter 1, page 11

Describing motion in two and three dimensions requires the use of vector quantities. Consider the scanning technology that you have selected for investigation. How is an image obtained? Does the scanning machinery move, or does the item that is being scanned move? Does the technology detect motion or the change in orientation of atomic and subatomic particles? Analyze the scanning technology you are investigating from the perspective of frames of reference. Develop a comprehensive description detailing how an image is formed based on the location of particles in a two- or three-dimensional space.

Unit 2 Energy and Momentum

Momentum

Chapter 4, page 150

The conservation of momentum is the principle that allows navigation in space. Conservation of momentum is a fundamental property of our universe. Conservation of momentum applies to planetary, human, and subatomic levels. Investigate possible applications of momentum conservation used in the scanning technology that you are investigating. If the conservation of momentum applies only to atomic and subatomic interactions, you might want to complete your analysis during your study of Unit 5, Matter-Energy Interface, in the textbook.

Energy Transformations

Chapter 5, page 217

Producing scanned images requires very controlled energy transformations. Investigate the energy path used by the technology you have chosen to investigate. Answer questions such as: What energy is directed at the item to be scanned? Is energy absorbed, transmitted, or both? What energy transformations occur within the scanned item? What energy transformations occur at the scanning receiver? Support your presentation with quantitative energy transformation analysis. Is there an economic, social, or safety aspect relating your technology to energy transformation issues?

Unit 3 Electric, Gravitational, and Magnetic Fields

Contact versus Non-Contact

Chapter 7, page 275

You might want to compare contact versus non-contact forces. A century ago, a medical examination conducted to identify an abnormal growth would have involved physical contact, because the doctor used touch to assess the patient. Current medical examinations are able to obtain a much clearer picture of an abnormal growth inside the body without ever coming into direct contact with the patient. Consider the scanning technology you have chosen in these terms.

Field Energy

Chapter 8, page 356

Ultimately, the energy stored in fields will be the basis for the operation of any scanning technology. Satellite-based technologies orbit Earth, held in position by the gravitational field. Medical scans employ powerful magnetic fields to obtain diagnostic imagery. Investigate how fields play a role in the production of images in the technology that you are investigating. You might want to consider your technology in terms of a quantitative application of Coulomb's law.

Unit 4 The Wave Nature of Light

How Far Can It Go?

Chapter 10, page 445

Energy transported in the form of oscillating electric and magnetic fields is the fundamental method used in most scanning technologies. This textbook provides an introduction to some of these applications in Chapter 10, Section 10.2, The Electromagnetic Spectrum. Consider those discussions while you complete your analysis. You might want to direct your arguments in terms of past and future scientific developments. What has been

accomplished? What new research is taking place? Are you able to predict how scanning technology might change in the next five years? Monetary and social arguments fit naturally into discussions based on possible changes in the field.

Unit 5 Matter-Energy Interface

Waves and Particles

Chapter 12, page 531

Scientific models evolve when theories are modified and validated by new experimental results. Physicists realize that electromagnetic radiation can be fully described only by using two completely different scientific models. Models are made by humans and therefore change as more knowledge is acquired. You might be able to demonstrate that a complete description of your chosen scanning technology requires both the wave and particle nature of electromagnetic radiation.

Nuclear Energy

Chapter 13, page 574

Nuclear energy provides electrical power not only to our homes, but also to most of the satellites orbiting overhead. Nuclear energy is used to probe living tissue in a variety of medical scanning technologies. Investigate nuclear decay rates of various materials and how they relate to your scanning technology. You might want to introduce safety and societal issues related to the use of nuclear material in the technology that you are investigating.

Wrap-Up

These ideas and questions are provided to help you develop your arguments related to a specific scanning technology. The ultimate shape of your presentation will be determined by the technology you choose to investigate, the issues you choose to address, and your own creativity. In order to prepare a high-quality, in-depth presentation, you will need to limit the amount of information that you attempt to present, focussing on the key points. Attempt to support your ideas with experimental evidence, mathematical verification, and comparisons to accepted scientific models. Give your project added relevance by relating your topic to key societal issues, such as economic or safety considerations.

Use your Course Challenge presentation to assist your learning by drawing together topics from each unit of study. As is often the case with any issue, the quality of discussion improves when knowledgeable links are made between topics.